

# Design and Evaluation of a Network-Monitoring System

*Research-in-Progress*

**Nithin Krishna**

Department of Electrical Engineering  
& Computer Science  
Wichita State University  
1845 Fairmount St, Wichita, KS 67260  
nithinkrishna87@yahoo.com

**Khawaja Saeed**

W. Frank Barton School of Business  
Wichita State University  
1845 Fairmount St, Wichita, KS 67260  
khawaja.saeed@wichita.edu

**David Xu**

W. Frank Barton School of Business  
Wichita State University  
1845 Fairmount St, Wichita, KS 67260  
david.xu@wichita.edu

## Abstract

*Effective design of network monitoring dashboard plays a crucial role in maintaining and managing the network operations infrastructure. An efficiently designed dashboard can communicate key information to network administrators, which would help them to solve network issues as quickly as possible. We argue that dashboard design impacts network monitoring performance. We design and evaluate two visualization designs: (i) Author Driven (AD) and (ii) Reader Driven (RD) in the context of network monitoring dashboards. Further, we also propose to evaluate the effect of Augmented Reality (AR) when it is added to the two designs (RD and AD) on network monitoring performance, namely, perceived effort and perceived learning performance. The initial results from the study show that, reader-driven dashboard design performed relatively better than author-driven design in terms of lower perceived effort and higher perceived performance.*

**Keywords:** Author Driven (AD) design, Reader Driven (RD) design, Augmented Reality (AR), dashboard, visualization

## **Introduction**

Network failures have huge financial repercussions as is evident from the recent outages at United Airlines, Wall Street Journal, and New York Stock Exchange<sup>1</sup>. According to Dunn & Bradstreet, 59% of Fortune 500 companies experience a minimum of 1.6 hours of downtime per week. The average cost of data center downtime across industries is approximately \$5,600 per minute (Evolver, 2014). To improve uptime, network monitoring dashboards are extensively used in various industries to maintain and manage networks.

Prior research has investigated design parameters involved in development of an efficient dashboard for a network operations environment (Ramly et al. 2012). The design space dimensions of data visualization play a crucial role in the development of an efficient Network Monitoring Dashboard (NMD). A dashboard can be described as a visualization interface that provides operational status of all the elements monitored by a Network Management System<sup>2</sup>. Without having a user-friendly and effective dashboard to display the network status, Network Management System will not be able to fully serve business requirement (Ramly et al. 2012). Design of network monitoring dashboard is critical in conditions wherein the company has to maintain and monitor business critical applications (Verge 2013). Any critical outage in network operations environment will create disruption and may result in a financial loss for the company (VOA 2014). An effective dashboard design will enable network engineers to proactively address service outage warnings and prevent critical outages that have financial repercussions (Fogarty 2013).

Excellence in the design of dashboard has become a mandatory requirement for today's network operations environment (Ramly et al. 2012). This thesis acts as a major motivation for this research study. When data in the dashboard is presented in an unorganized manner, the end result will be a dashboard with poor visualization. Visualization is defined as a graphical representation of collected data in an organized pattern which would enable the end user to understand and analyze the meaning of the data content in an effective manner (Ramly et al. 2012). An excellent well-versed visualization dashboard enables the end user (e.g. Network Engineer) to proactively monitor and take appropriate action so as to consistently maintain and manage the network status with high availability.

In this research work, we propose to evaluate the performance of four different network monitoring dashboards (Segel and Heer 2010), namely Author-Driven and Reader-Driven with/without Augmented Reality. We will evaluate their performance in terms of perceived effort and perceived learning performance. The description and background about these four types of dashboard designs and two dependent variables are reviewed in the next section.

## **Literature Review**

### ***Network-Monitoring System***

Network-Monitoring System is a system that constantly monitors the whole computer network for slow or failing components and notifies the network responsible person via email, SMS or other alarms in case of outages (Khan et al. 2013; Ten et al. 2009). We focus on the design of Network-Monitoring System for two reasons. First, networking system is the backbone of other information systems, such as online ordering systems and payroll systems. The failure of networking system will lead to malfunction of other systems in an organization. Thus, it is important to closely monitor the whole network. Second, large organizations have a big network topology, thus the manual network monitoring causes waste of time to pinpoint a problem location (Khan et al. 2013; Talpade et al. 2002). A Network-Monitoring System can

---

<sup>1</sup> <http://money.cnn.com/2015/07/08/technology/united-nyse-wsj-down/>

<sup>2</sup> [www.cio.com/networkmonitoring](http://www.cio.com/networkmonitoring)

help network personals in locating an exact problem, diagnose it and resolve the issue quickly. Thus, the study of Network-Monitoring System has a greater sense of urgency.

### **Author Driven and Reader Driven Design**

Sophisticated dashboard designs have evolved that focus on data analysis and data exploration. The selection of design criteria plays a vital role in developing an efficient network monitoring dashboard (Segel and Heer 2010; Ramly et al. 2012). *Narrative structure tactics* is one of the design space dimensions in data visualization, which related to mechanisms such as: (i) ordering, (ii) messaging and (iii) interactivity (Segel and Heer 2010). This design space dimension is more relevant to a network monitoring dashboard, so we selected these mechanisms as the major criteria for developing the different dashboard designs. According to Segel and Heer (2010), *ordering* defines the arrangement of the path available to the end user on a visualization dashboard. This path can be of a linear, random or a user directed path; *messaging* refers to the method in which the observations and comments get communicated to the end user. Common mechanisms in messaging are labels, headlines, captions, comments etc; *interactivity* defines the multiple methods in which the user can manipulate the visualization dashboard. Common design elements in interactivity are filtering, navigation buttons, selection, drilldown, zooming, time sliders, searching, hover-highlighting (Segel and Heer 2010). Prior research suggests that different dashboard designs can be developed by manipulating the levels of design elements such as messaging, interactivity and ordering. In other words, variation in design elements can be used to develop different dashboard designs.

Two contrasting visualization designs have been highlighted: (i) Author Driven and (ii) Reader-Driven (Segel and Heer 2010). An author driven design approach follows a linear path throughout the visualization space, with minimal interactivity mechanism, but relies extensively on the messaging element. Examples of Author Driven approach include film, non-interactive slideshows, and educational videos. In these cases, the audiences cannot change the presentation order, do not have an opportunity to interact with the presentation materials, but instead depend on the messages to understand the visualization. Because of this narrative structure, the author driven based dashboard is expected to work better for a business requirement, where we just need to convey the top level or overall view of the network status to the end user (Segel and Heer 2010; Ramly et al. 2012). A reader driven approach has no predefined ordering, limited messaging content, but offers a high degree of interactivity. Examples of Reader-Driven approach include visual analysis tools such as Tableau. Here users are not constrained by the predefined order of the visualization, are free to interactively explore the data, and rely less on messages to grasp the essence of the visualization. Hence this approach may work better for business requirements focused on tasks such as pattern discovery, drill down study followed by in-depth understanding of the data and hypothesis formation. Dashboard in Figure 1 includes elements associated with a reader driven approach.

Recently, Segel and Heer (2010) identified some patterns and structures that news media uses to introduce storytelling in visualizations and classified narrative visualizations along a spectrum of author-driven and reader-driven approaches. However, two gaps exist in the visualization literature. One, little empirical research has been conducted to compare the differences between the effectiveness of author-driven and reader-driven approaches. Thus, it is not clear which approach offers better outcomes. Two, Segel and Heer (2010) called for research to examine what mix of author-driven and reader-driven elements is best for different purposes. Network outage and problems require immediate attention from the network personnel. In response to an emergency situation with time pressure, it is not clear whether author-driven and reader-driven is better for such purpose. Thus, our study will not only advance the literature by empirically examining the differences between the two approaches in the network visualization domain, but also stimulate future research to examine the mixed element of author-driven and reader-driven approaches.

As such, we focus on two visualization approaches of networking monitoring systems: (i) Author Driven (AD) Design and (ii) Reader Driven (RD) Design (see Table 1). The main features of the author driven design are: (i) Linear Ordering (ii) High degree of Messaging and (iii) Low degree of Interactivity. The

main features of the reader driven design are: (i) Low degree of Ordering (ii) Low degree of Messaging and (iii) High degree of Interactivity (Segel and Heer 2010).



**Figure 1: Dashboard with Reader Driven Approach Features**

<b>Table 1. Design Levels for Development of Network Monitoring Dashboards</b>			
	<b>Interactivity</b>	<b>Messaging</b>	<b>Ordering</b>
<b>Author Driven (AD)</b>	Low	High	High
<b>Reader Driven (RD)</b>	High	Low	Low

The network monitoring outcomes that we explore in this research are: (i) Perceived effort and (ii) Perceived learning performance. Effort refers to the physical or mental exertion experienced in understanding the status of the network (Paas et al. 2003). As previous research has demonstrated (Xu et al. 2009), the effort spent by the person who is exposed to the dashboard design should be minimized so as to achieve higher performance. Learning performance is users' perceptions of how a dashboard is helpful for them to understand network problem (Jiang and Benbasat 2007). A good dashboard design is expected to aid the end user in understanding the network problem and resolving the network problem as quickly as possible.

### **Augmented Reality**

*Augmented Reality (AR)* is a type of virtual reality that provides the duplicate version of a real world environment in a computer (Tang et al. 2003). The AR systems generate a view for the end user that combines elements seen in the real world with virtual elements generated by the computer (Chen et al. 2009). Figure 2 provides an example of an augmented reality dashboard from weather.com. The main goal of AR is to provide a visualization dashboard in which the gap between the virtual and real

environment is minimized. Thus, a visualization dashboard enhanced with the augmented reality can lead to better network monitoring experience (Tang et al. 2003; Chen et al. 2009).



### Cognitive Load Theory

The relationship between performance parameters and network dashboard design can be explained through the lens of Cognitive Load Theory (CLT) (Paas et al. 2010; Kalyuga 2011). CLT is defined as an instruction theory which describes the cognitive architecture of a human being. *Cognitive load* can be defined as the amount of load acting upon the working memory (WM) at any instance of time (Paas et al. 2010). CLT primarily focuses on the WM and its relationship with human performance (Sweller 2010). The efficient management of WM acts as a key factor in achieving good performance efficiency (Paas et al. 2003, 2004). The primary place to process the information received from sensory memory is WM. The major task of the dashboard designer is to facilitate the use of WM within its capacity limit so as to achieve higher performance efficiency (Paas et al. 2010; Kalyuga 2011). The capacity of WM is very limited (Kalyuga 2011). When WM is overloaded with too much information overall cognitive load increases resulting in poor performance efficiency (Paas et al. 2010).

The CLT classifies cognitive load in three different types: (i) Intrinsic load, (ii) Extraneous load and (iii) Germane load (Paas et al. 2010). The sum of these three loads refers to the capacity of the working memory. *Intrinsic load* is defined as the load imposed by the nature of the material present in the visualization design which cannot be altered (Paas et al. 2003, 2004). When the complexity of the design is high, the user will experience more intrinsic load on the working memory (WM) (Kalyuga 2007).

*Extraneous Cognitive Load* is defined as a load that arises due to situations in which an individual has to process redundant information. These processes demand a good amount of working memory capacity which eventually results in a split-attention effect or attention diversion for the end user (Sweller and Chandler 1994). This load is usually affected by the manner in which the information is presented on a dashboard design. Also this load can be manipulated with instructional intervention. The effect of extraneous load can be reduced by minimizing the split attention effect and redundant processing patterns (like searching, matching etc.) in the visualization design (Sweller 1988).

*Germane Load* refers to the mental effort required by the end user to comprehend the material presented in the dashboard design. This load primarily refers to the automation, construction, and processing of schemas. Hence it is very important for the dashboard designers to promote the germane load and redirect the end user towards better schema construction which would result in better performance (Paas et al. 2003, 2004).

The performance of the design can be improved by minimizing the cognitive load (Sweller and Chandler 1994). Whenever the total cognitive load imposed by the design is within the capacity limits of WM, the end user will be able to process the information on the visualization dashboard with a better processing capability. The task given in the dashboard can be understood in a shorter period of time which improves

performance. The performance of a human brain has a direct interconnection with the cognitive load acting upon the working memory (Sweller 2010). Overall, CLT suggests that the dashboard designer can enhance the performance and processing of working memory by reducing the extraneous load and increasing the germane load (Sweller 1988, 1994). As intrinsic load cannot be modified, the designer needs to mainly focus on varying the level of extraneous load and germane load so as to achieve better performance (Sweller 2010).

## **Hypothesis Development**

The complexity in understanding the dashboard gets reduced due to the interactivity factor present in the RD design. Interactivity minimizes cognitive load acting upon the working memory of the end user. As a result, the end user will spend less effort on understanding the RD dashboard design when compared to the AD design. In addition, prior research has found that high interactivity leads to perceived enjoyment (Jiang and Benbasat 2007; Xu et al. 2014; Yoo et al. 2010) and, in turn, leads to lower perceived effort (Xu et al. 2014). This is because the exploratory nature of the experience can arouse users' positive affect (Jiang and Benbasat 2007). Users with positive affect underestimate the difficulty associated with the technologies, resulting in a lower level of perceived decision effort (Agarwal and Karahanna 2000). The low degree of ordering present in the RD design provides users with the flexibility to choose their own navigation path to understand the task given in the dashboard design. This would reduce the extraneous load and enhance the germane load acting upon the working memory. Hence the user will be able to better understand and recall the specific and general details of the network status. As a result, the learning outcome of the person who is exposed to RD design will be better than AD design. The high degree of messaging and ordering may cause attention diversion or split attention effect for the user who is exposed to the AD design. This increases the extraneous load acting on the WM beyond its processing capacity, which can be the main reason for reduce performance when exposed to AD design as compared to RD design. Thus, we propose

- H1: RD design will lead to lower perceived effort than AD design.
- H2: RD design will lead to higher perceived learning performance than AD design.

Augmented Reality (AR) plays a significant role in the cognitive load experienced by the human brain when exposed to the dashboard design (Tang et al. 2003). Presence in a virtual environment refers to the subjective experience of being in a computer generated environment (Tang et al. 2003). This presence is defined as the degree of attention shifted from real world to virtual environments as if the users were situated in that artificial setting, a feeling of "being there" (Tang et al. 2003; Chen et al. 2009). The major conditions for the presence in a virtual environment are as follows: (i) immersion, (ii) selective attention and (iii) involvement. If users pay more attention to the virtual reality environment, they are more involved in the virtual reality experience and may immerse themselves into it. Higher immersion results in good understanding with improved accuracy and efficiency. In addition, high presence in the virtual reality environment helps the user better understand the task at a reduced cognitive load. As the amount of cognitive load is reduced, the WM can process the information faster, which improves the overall efficiency of processing and understanding the visualization task. Overall, reduced cognitive load effect due to high presence helps in achieving higher performance (Tang et al. 2003).

- H3: AR design will lead to lower perceived effort than non-AR design.
- H4: AR design will lead to higher perceived learning performance than non-AR design.

## **Methodology**

We designed four different network monitoring dashboards for this study: (i) Author Driven (AD) (ii) Reader Driven (RD) (iii) Augmented Reality in Author Driven (AAD) and (iv) Augmented Reality in Reader Driven (ARD). Thus, it is a 2 (AD vs. RD) X 2(with/without AR) experiment design. Four web-based dashboards were designed, built, and deployed. We designed a survey questionnaire based on scales which were validated by prior studies. Participants were exposed (or will be exposed to) to different dashboard designs, and then asked to complete the survey questionnaire after reviewing the dashboards.

## Design Components

The major network status parameters displayed on the dashboard were: (i) CPU Utilization (ii) Disk Utilization (iii) Network Bandwidth Availability. The information was centered on three different servers for a small scale network monitoring environment. The various states of the servers monitored in the dashboard were: (i) Critical, (ii) Warning and (iii) OK.

### Design of Reader Driven (RD) Dashboard

The design criteria followed to develop the RD based network monitoring dashboard are as follows: (i) Low degree of ordering (ii) Low degree of messaging (iii) High degree of interactivity. Low degree of ordering was achieved on the front end by providing random sequence for the arrangement of server details. We followed a sequence which offered the ability to select/view the things in a user defined order. The messaging content was reduced to a low level. The high degree of interactivity was implemented by providing a drill down view and chart type change options in the dashboard design. The drill down view helped the end user to carry out an in-depth analysis of the device alert along with supporting trend charts. The chart type changing option also contributed towards the high interactivity factor. This option allowed end user to analyze the trend in patterns of the individual servers in the form of a bar graph.

### Design of Author Driven (AD) Dashboard

The design criteria for the development of AD based dashboard are as follows: (i) Linear ordering (ii) High degree of messaging and (iii) Low degree of interactivity. The linear ordering pattern follows a predefined ordering sequence, where the information is displayed from left to right based on their criticality/priority of the service alert. The server that needs attention will be displayed on the left most end and the display sequence followed a descending pattern (from left to right) based on the priority of the incident. An incident can be defined as any unexpected service interruption which can affect the normalcy state of a network status. The high degree of messaging criteria was achieved by providing a large amount of messaging on the tactical overview table on the front end. The drill down and chart change options were not used in the AD design, ensuring a low degree of interactivity.

**Table 2. Summary of Specific Design Elements across Dashboards**

Items	Messaging	Ordering	Interactivity
<b>Reader Driven (RD)</b>	Status Message, (ii) Source IP address (iii) Device Category (iv)Severity, (v) Last check time stamp updated	(i)No predefined order for navigation, (ii) Avg. Disk, Avg. CPU and Avg. Network utilization statistics arranged in random sequence which will guide us towards specific alert details.	(i) Drill down option (ii) Trend Chart change option
<b>Author Driven (AD)</b>	(i)Status Message, (ii)Source IP address, (iii)Device Category (iv)Severity, (v) Last check time stamp updated, (vi) Detailed troubleshooting steps, (vii) Description of impact, urgency and outage action, (viii) device and alert description in detail, (ix)Outage action described in detail, (x) Last time stamp check detailed information	(i)Predefined order for navigation (ii)The server which needs prior attention will be displayed on the left most end. (iii)The display sequence followed a descending pattern (from left to right) based on the priority of the incident.	(i)Performance trend chart of last 24hrs for CPU, Disk and network utilization respectively.

<b>Augmented Reality (AR)</b>	(i) Static images which represents the CPU, Disk and Network availability respectively. (ii) Virtual reality based background effect which represents a global network operations environment.
-------------------------------	---

### ***Design of Augmented Reality (AR) Dashboard***

To evaluate the impact of Augmented Reality (AR) approach over the performance variables, we developed two additional dashboard designs (i) Augmented Reality in Author Driven (AAD) design and (ii) Augmented Reality in Reader Driven (ARD) design. The ARD design approach provides a virtual reality feeling on a computer. The end user experiencing the dashboard should be able to relate the dashboard with the real world with the help of animations, static images, background effects etc. In this scenario, we integrated the AR approach with the help of the following design elements: (i) Static images which represents the CPU, Disk and Network availability and (ii) Background effect that represents a global network operations environment (Segel and Heer 2010; Tang et al. 2003). These two AR design criteria were implemented in the existing author driven and reader driven dashboard designs so as to develop AAD and ARD designs respectively. Table 2 presents the overview of the experiment design.

### ***Measurements***

Table 3 lists the sample measurements for the manipulation check and dependent variables. The sources of these measurements are based on Segel and Heer (2010) and Jiang and Benbasat (2007). A 7-point Likert scale ranging from strongly disagree (1) to strongly agree (7) was adopted for these questions.

<b>Table 3. Measurement Items</b>	
<b>Constructs</b>	<b>Measurements</b>
Perceived ordering	<ul style="list-style-type: none"> <li>• I could select the order in which the dashboard presented the information.</li> <li>• The dashboard allowed me to specify my preferred order to present the information.</li> <li>• I had limited control over the order in which the dashboard presented the information.</li> <li>• Dashboard presented information in a predefined order.</li> </ul>
Perceived messaging	<ul style="list-style-type: none"> <li>• The amount of written messages on the dashboard was high.</li> <li>• Many written messages were provided on the dashboard.</li> <li>• The amount of written messages provided on the dashboard was low.</li> </ul>
Perceived interactivity	<ul style="list-style-type: none"> <li>• I was able to interact with the dashboard.</li> <li>• The dashboard responded to my commands.</li> <li>• The level of interactivity in the dashboard was high.</li> </ul>
Perceived augmented reality	<ul style="list-style-type: none"> <li>• The dashboard augmented my network monitoring experience.</li> <li>• The dashboard has elements that relate to the real world.</li> <li>• The dashboard gave me a virtual reality feeling.</li> <li>• The dashboard has a real world network monitoring environment.</li> </ul>
Perceived effort	<ul style="list-style-type: none"> <li>• I spent a lot of effort on identifying the issue with the network.</li> <li>• I spent a lot of effort on diagnosing the problem with the network.</li> </ul>
Perceived learning outcome	<ul style="list-style-type: none"> <li>• The dashboard assisted me in learning about the cause of the network problem.</li> <li>• The dashboard helped me in formulating the steps needed to avoid the network problem in the future.</li> </ul>

### ***Initial Sample***

We conducted our initial testing with a set of 25 students who were taking courses that included a significant amount of computer networking content. The initial testing was conducted at a mid-west university with a set of graduate and undergraduate students. Subsequent testing was conducted at a data



storage company (Firm A). 24 employees participated in the actual testing from the Firm A. These employees were part of the storage based network operations support team at Firm A. Both student and employee subjects were assigned to either the AD or RD condition. In total, survey was completed by 49 subjects. This sample comprised 46 males and 3 females with an average age of 28 years. The average of the participants' networking knowledge is 4.26/7.00.

### ***Manipulation Check***

We first checked the success of the manipulations of RD vs. AD. Results indicate that subjects perceived a higher level of ordering (mean difference =1.0,  $p<0.01$ ) and messaging (mean difference =0.88,  $p<0.05$ ), and a lower level of interactivity (mean difference =-2.31,  $p<0.01$ ) in the AD as compared to those in RD. Therefore, the manipulation of RD vs. AD was successful.

### ***Initial Hypotheses Testing***

The correlation between perceived effort and perceived learning performance is -0.28, demonstrating good discriminant validity. An independent samples t-test was conducted between RD and AD in terms of perceived effort and perceived learning performance. Although the results are not significant at  $p=0.05$ , the results are consistent with our hypothesized direction: As compared to AD, RD lead to a lower level of perceived effort (mean difference=-0.38;  $p=0.29$ ) and a high level of perceived learning performance (mean difference= 0.53;  $p=0.18$ ). With more sample size, we predict that the results will become significant at the 0.05 level.

### ***Discussion and Future Work***

The initial results indicate that RD dashboard design offered a better solution in the network monitoring context. It seems the enhanced interactivity, low messaging, and low ordering that are key characteristics of the RD design reduce the complexity of understanding the visualization, minimize the cognitive load, and enhance the user's performance in monitoring the network. The low degree of ordering in the RD design provides the user with the flexibility to choose a personal navigation path to understand the task given in the dashboard design. This reduces the intrinsic load and enhances the germane load. Hence the user will be able to understand and learn better about network status. This is a likely reason why the perceived learning performance of participants exposed to RD design would be better than those exposed to the AD design.

We plan to continue to collect more data for the RD and AD treatment conditions to increase the statistical power. We also plan to recruit subjects for the two conditions with Augmented Reality in order to test H3 and H4. Other possible research opportunity is to include other outcome evaluations such as positive affect (Xu et al. 2012). Future research can also focus on understanding the underlying mechanism through which the dashboard design elements exert influence on performance parameters. It would be interesting to expand the design elements to include other design elements and assess the role of these aspects in design of network monitoring dashboards and network monitoring performance.

### ***References***

- Agarwal, R., and Karahanna, E. 2000. "Time Flies When You're Having Fun: Cognitive Absorption and Beliefs about Information Technology Usage," *MIS Quarterly* (24:4), pp. 665-694.
- Chen, Y. C., Wang, S. J., & Chiang, Y. L. 2009. "Exploring the Effect of Presence in an AR-based Learning Environment," In *13th Global Chinese Conference on Computers in Education, Taipei*.
- Evolgen, 2014, "Downtime, Outages, and Failures – Understanding their True Costs," <http://www.evolgen.com/blog/downtime-outages-and-failures-understanding-their-true-costs.html>.

- Fogarty S. 2013, "Deadly Downtime: The Worst Network Outages of 2013," <http://www.informationweek.com/infrastructure/cloud-infrastructure/deadly-downtime-the-worst-network-outages-of-2013/d/d-id/1113240>.
- Jiang, Z., & Benbasat, I. 2007. "Investigating the Influence of the Functional Mechanisms of Online Product Presentations," *Information Systems Research*, (18:4), 454-470.
- Jiang, Z., & Benbasat, I. 2007. "The Effects of Presentation Formats and Task Complexity on Online Consumers' Product Understanding," *MIS Quarterly*, pp. 475-500.
- Kalyuga, S. 2011. "Cognitive Load Theory: How Many Types of Load Does it Really Need?" *Educational Psychology Review* (23:1), pp.1-19.
- Khan, R., Khan, S. U., Zaheer, R., & Babar, M. I. 2013. "An Efficient Network Monitoring and Management System," *International Journal of Information and Electronics Engineering*, (3:1), 122-126.
- Paas, F., Renkl, A., & Sweller, J. 2003. "Cognitive Load Theory and Instructional Design: Recent Developments," *Educational Psychologist* (38:1), pp.1-4.
- Paas, F., Renkl, A., & Sweller, J. 2004. "Cognitive Load Theory: Instructional Implications of the Interaction between Information Structures and Cognitive Architecture," *Instructional science* (32:1), pp.1-8.
- Paas, F., Van Gog, T., & Sweller, J. 2010. "Cognitive Load Theory: New Conceptualizations, Specifications, and Integrated Research Perspectives," *Educational Psychology Review*, (22:2), pp.115-121.
- Ramly, N. N., Nor, F. M., Ahmad, N. H., & Aziz, M. H. 2012. "Comparative Analysis on Data Visualization for Operations Dashboard," *International Journal of Information and Education Technology* (2:4).
- Segel, E., & Heer, J. 2010. "Narrative Visualization: Telling Stories with Data." *IEEE Transactions on Visualization and Computer Graphics* (16:6), pp.1139-1148.
- Sweller, J. 1988. "Cognitive Load During Problem Solving: Effects on Learning," *Cognitive science* (12:2), pp. 257-285.
- Sweller, J. 2010. "Element Interactivity and Intrinsic, Extraneous, and Germane Cognitive Load," *Educational psychology review* (22:2), pp. 123-138.
- Sweller, J., & Chandler, P. 1994. "Why Some Material Is Difficult to Learn," *Cognition and Instruction* (12:3), pp. 185-233.
- Talpade R., G. Kim, and S. Khurana, 2002 "NOMAD: Traffic-Based Network Monitoring Framework for Anomaly Detection," *IEEE International Symposium on Computers and Communications* 9 Morristown, NJ.
- Tang, A., Owen, C., Biocca, F., & Mou, W. 2003, "Comparative Effectiveness of Augmented Reality in Object Assembly," In *Proceedings of the SIGCHI conference on Human factors in computing systems* (pp. 73-80). ACM.
- Ten D., S. Manickam, S. Ramadass, and H. A. Bazar, 2009. "Study on Advanced Visualization Tools In Network Monitoring Platform," in *Third UKSim European Symposium on Computer Modeling and Simulation*, EMS '09, Minden Penang, Malaysia.
- Verge, J. 2013. "Network Issues Cause Amazon Cloud Outage," <http://www.datacenterknowledge.com/archives/2013/09/13/network-issues-cause-amazon-cloud-outage/>
- VOA, 2014, "China Experiences Major Internet Outage; Cause Unclear," <http://www.voanews.com/content/china-experiences-major-internet-outage-cause-unclear/1835073.html>.
- Xu D. J., I. Benbasat, R. Cenfetelli, "The Effect of Service Quality, Sacrifice and Service Outcome on Online Customer Loyalty," *Proceedings of the International Conference on Information Systems (ICIS)*, Phoenix, Arizona, USA, December 15-19, 2009.
- Xu D. J., I. Benbasat, R. Cenfetelli, 2014. "The Nature and Consequences of Trade-off Transparency in the Context of Recommendation Agents," *MIS Quarterly* 38(2), 379-406.
- Xu D. J., R. Cenfetelli, K. Aquino, 2012. "The Influence of Media Cue Multiplicity on Deceivers and Those Who Are Deceived," *Journal of Business Ethics* 106(3), pp. 337-352.
- Yoo, W-S., Lee, Y., and Park, J. 2010. "The Role of Interactivity in E-tailing: Creating Value and Increasing Satisfaction," *Retailing and Consumer Services* (17), pp. 89-96.